

**Claims**

1 A method of determining one or more physical properties of a rolled smoking  
article or filter rod, said method comprising disposing a rolled smoking article or filter rod  
within a field of view, illuminating said field of view, imaging said rolled smoking article  
5 or filter rod within said field of view to form an image, and analysing said image to  
determine one or more physical properties of said rolled smoking article or filter rod.

2 A method as claimed in claim 1, wherein said image is a digital image.

3 A method as claimed in claim 2, characterised by electronically processing said  
digital image to determine said one or more physical properties.

10 4 A method as claimed in any of claims 1 to 3, characterised by illuminating said  
field of view with diffuse light and using light reflected from said rolled smoking article or  
filter rod to form said image.

5 A method as claimed in claim 4, wherein said one or more physical properties  
include the length of the rolled smoking article or filter rod.

15 6 A method as claimed in claim 5, characterised by moving said rolled smoking  
article or filter rod axially whilst locating one end thereof with respect to said field of view  
until the other end is disposed within the field of view, imaging said rolled smoking article  
or filter rod to form said image, processing the image to locate said other end with respect  
to the field of view, and thereafter determining the length of said rolled smoking article or  
20 filter rod from the positions of said ends.

7 A method as claimed in claim 6, characterised by advancing said rolled smoking  
article or filter rod axially until said one end is located at a first predetermined position  
with respect to the field of view corresponding to a predetermined nominal length of the  
rolled smoking article or filter rod and the other end is disposed within said field of view in  
25 the vicinity of a first nominal position corresponding to said nominal length, processing  
said image to determine the actual position of said other end, and determining the length of  
the rolled smoking article or filter rod by calculating the difference between said first  
nominal and actual positions and adding or subtracting that difference to or from the  
nominal length.

30 8 A method as claimed in claim 7, characterised by processing said image within a  
first limited region of interest of said field of view, which first region of interest  
encompasses all likely actual positions of said other end of the rolled smoking article or  
filter rod when said one end is located at said first predetermined position.

9 A method as claimed in claim 6, claim 7 or claim 8, wherein said rolled smoking article or filter rod comprises a rolled smoking article having first and second adjacent longitudinal sections and an outer tipping layer which extends axially from a first end of the rolled smoking article over one of said first and second sections and overlaps the interface between said sections to cover partially the other section, said outer tipping layer  
5 terminating remote from said first end in an edge, and said image is processed to determine the axial length of said outer tipping layer.

10 A method as claimed in claim 9, characterised by determining the axial orientation of the rolled smoking article, advancing said rolled smoking article axially whilst locating said one end thereof with respect to said field of view until the edge of the outer tipping layer is disposed within the field of view, imaging said rolled smoking article to form said image, processing the image to locate said edge with respect to the field of view, and thereafter determining the length of said outer tipping layer from the position of said edge, the position of said one end, and, depending on the axial orientation of the rolled smoking article, the length of the rolled smoking article.  
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11 A method as claimed in claim 10, characterised by advancing said rolled smoking article or filter rod axially until said one end is located at a second predetermined position with respect to the field of view corresponding to a predetermined nominal distance between said edge, and the one end of the rolled smoking article and the edge is disposed within said field of view in the vicinity of a second nominal position corresponding to said nominal distance, processing said image to determine the actual position of said edge, and determining the actual distance between said edge and the one end of the rolled smoking article by calculating the difference between said second nominal and actual positions and adding or subtracting that difference to or from the nominal distance, the length of said  
20 outer layer being equal to said actual distance or, depending on the axial orientation of the rolled smoking article, the length of the rolled smoking article minus said actual distance.

12 A method as claimed in claim 11, characterised by processing said image within a second limited region of interest of said field of view, which second region of interest encompasses all likely actual positions of said edge when said one end is located at said  
25 second predetermined position.

13 A method as claimed in any of claims 4 to 12, further comprising rotating said rolled smoking article or filter rod about its axis within said field of view and repeatedly sampling the image.  
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14 A method as claimed in claim 13, characterised by processing each image sample to measure the diameter of said rolled smoking article or filter rod in each image sample and using the measurements to obtain one or more physical properties of said rolled smoking article or filter rod selected from the mean diameter, ovality, circumference, roundness and shape of said rolled smoking article or filter rod.

15 A method as claimed in claim 14, characterised by determining the diameter of the rolled smoking article or filter rod in each image sample by processing the image sample to locate the two opposite edges of the rolled smoking article or filter rod in profile and calculating the distance between said opposite edges.

16 A method as claimed in claim 15, characterised by processing each image sample within two predetermined, laterally spaced regions of interest of said field of view to locate said two opposite edges, which regions of interest are determined on the basis of the nominal diameter of the rolled smoking article or filter rod.

17 A method as claimed in claim 14, claim 15 or claim 16, wherein the diameter of said rolled smoking article or filter rod is measured at two or more axially spaced locations on said rolled smoking article or filter rod.

18 A method as claimed in any of claims 13 to 17, wherein said rolled smoking article or filter rod comprises one or more circumferential markers adapted to indicate the rotational orientation of the rolled smoking article or filter rod, and said processing step includes processing said samples to determine a complete revolution of the rolled smoking article or filter rod.

19 A method as claimed in any of claims 13 to 18, characterised by determining the axial direction of a rolled smoking article which is axially asymmetric such that said rolled smoking article is directional and comprises at least one outer layer which is wrapped circumferentially around said rolled smoking article to overlap itself thereby to form a longitudinal seam, and processing said image samples to determine the wrapping direction of said outer layer relative to the direction of said rolled smoking article.

20 A method as claimed in claim 19, wherein said image samples are processed to determine the position of said longitudinal seam by detecting the position of a shadow cast by said seam as the rolled smoking article rotates.

21 A method as claimed in claim 20, characterised by processing each image sample to detect the presence of said shadow in two predetermined, laterally spaced regions of interest of said field of view, the presence of said shadow in one or other of said regions of interest being determinative of the direction of wrapping of the outer layer, the regions of

interest being determined on the basis of a predetermined nominal width of the rolled smoking article.

22 A method as claimed in claim 20 or claim 21, characterised by illuminating said rolled smoking article obliquely to enhance the shadow cast by said seam.

5 23 A method as claimed in any of claims 19 - 22, wherein said rolled smoking article comprises two or more outer layers, each of which outer layers is wrapped circumferentially around the rolled smoking article to overlap itself to form an axially extending seam, and said image is processed to determine the wrapping direction of each outer layer relative to the direction of the rolled smoking article.

10 24 A method as claimed in any preceding claim, wherein said rolled smoking article or filter rod is back-lit to reveal internal physical properties of said rolled smoking article or filter rod and said image is processed to determine said internal physical properties.

25 A method as claimed in claim 24, wherein said rolled smoking article or filter rod is back-lit with infra-red light.

15 26 A method as claimed in claim 24 or claim 25, wherein said rolled smoking article or filter rod comprises a rolled smoking article having a first filter section and a second adjacent tobacco rod section, and said rolled smoking article is illuminated to show an end face of the filter section at the interface between said sections, and said image is processed to determine the length of said filter section between said end face and the other end of the filter section at the end of the rolled smoking article.

20 27 A method as claimed in claim 26, characterised by determining the axial orientation of the rolled smoking article, moving said rolled smoking article axially whilst locating one end thereof with respect to said field of view until said end face is disposed within the field of view, imaging said rolled smoking article to form said image, processing the image to  
25 locate said end face with respect to the field of view, and thereafter determining the length of said filter section from the positions of said one end and of said end face and, depending on the orientation of the rolled smoking article, on the length of the rolled smoking article.

28 A method as claimed in claim 27, characterised by advancing said rolled smoking article axially until said one end is located at a third predetermined position with respect to  
30 the field of view corresponding to the predetermined nominal length of the filter section and the end face is disposed within said field of view in the vicinity of a third nominal position corresponding to said nominal length, processing said image to determine the actual position of said end face, and determining the length of the filter section by calculating the difference between said third nominal and actual positions and adding or

subtracting that difference to or from the nominal length, the length of said filter section being equal to said actual distance or, depending on the axial orientation of the rolled smoking article, the length of the rolled smoking article minus said actual distance

29 A method as claimed in claim 28, characterised by processing said image within a  
5 third limited region of interest of said field of view, which third region of interest encompasses all likely actual positions of said end face when said one end is located at said third predetermined position.

30 A method as claimed in any of claims 26 to 29, wherein said rolled smoking article  
10 further comprises an outer tipping layer extending axially from a first end of the rolled smoking article over said first filter section and including an overlapping portion that overlaps the interface between said sections to cover partially the tobacco rod section, and said image is processed to determine the axial length of said outer tipping layer, and the length of said overlapping portion is calculated from the difference between the length of the tipping layer and the length of the filter section.

15 31 A method as claimed in any of claims 25 to 30, wherein said image is processed to detect any voids in the rolled smoking article or filter rod.

32 Apparatus for determining one or more physical properties of a rolled smoking article or filter rod, said apparatus comprising:

20 imaging means defining a field of view, said imaging means being adapted for imaging a rolled smoking article or filter rod in said field of view;

means for positioning a smoking article or filter rod in said field of view;

illuminating means for illuminating said field of view; and

processing means for processing said image to determine one or more physical properties of a smoking article or filter rod in said field of view.

25 33 Apparatus as claimed in claim 32, wherein said imaging means are adapted for forming a digital image of said smoking article or filter rod.

34 Apparatus as claimed in claim 33, wherein said processing means are adapted for processing said digital image electronically for determining said one or more physical properties.

30 35 Apparatus as claimed in claim 33, wherein said processing means are adapted for repeatedly sampling said image.

36 Apparatus as claimed in any of claims 32 to 35, wherein said illuminating means are adapted to cast diffuse light onto said field of view.

37 Apparatus as claimed in claim 36, wherein said imaging means define an optical viewing axis and said illuminating means comprise one or more sidelights which are positioned laterally of said optical axis.

38 Apparatus as claimed in claim 37, wherein said illuminating means comprise two  
5 sidelights positioned on opposite sides of said optical axis.

39 Apparatus as claimed in any of claims 32 to 38, wherein said illuminating means comprise a backlight adapted for backlighting a smoking article or filter rod positioned in said field of view.

40 Apparatus as claimed in claim 39, wherein said backlight comprises an infra-red  
10 light.

41 Apparatus as claimed in any of claims 32 to 40 wherein said imaging means comprise a digital camera.

42 Apparatus as claimed in any of claims 32 to 41, further comprising means for rotating a smoking article or filter rod about its axis in said field of view.

43 Apparatus as claimed in claim 42, wherein said rotating means comprise two  
15 juxtaposed rollers, which rollers are positioned side-by-side so as to define a groove therebetween which groove is adapted to receive said smoking article or filter rod, and means for rotating one or both of said rollers thereby to cause said smoking article or filter rod to rotate.

44 Apparatus as claimed in any of claims 32 to 39, further comprising means for moving a smoking article or filter rod axially relative to the field of view.

45 Apparatus as claimed in claim 44, further comprising means for locating one end of a smoking article relative to the field of view.

46 Apparatus as claimed in claim 45 wherein said moving means comprise a pusher  
25 adapted to engage one end of a smoking article or filter rod, and a linear actuator for moving said pusher along a predetermined path, and said locating means are adapted for indicating the position of said pusher.

47 Apparatus as claimed in claim 46, wherein said linear actuator comprises a stepper motor having an encoder for locating of said pusher relative to the field of view.

48 Apparatus as claimed in claim 45, claim 46 or claim 47, characterised in that said  
30 apparatus further comprises control means for controlling said moving means and processing means, said control means comprising a database adapted to store a first predetermined nominal length for the rolled smoking article or filter rod and being adapted to control said moving means to move the one end of the rolled smoking article or filter

rod to a first predetermined position with respect to said field of view corresponding to said first nominal length such that the other end is disposed within said field of view, and thereafter to control said processing means to process said image to locate said other end with respect to the field of view and to determine the actual length of the rolled smoking article or rod from the locations of said one and other ends.

49 Apparatus as claimed in claim 47, characterised in that said control means are adapted to derive a first nominal position for said other end within said field of view when the one end is positioned at said first predetermined position, said first nominal position corresponding to said first nominal length, and said processing means are adapted to locate the actual position of said other end and calculate the difference between said actual and nominal positions, the length of the rolled smoking article or filter rod being equal to the first nominal length plus or minus said difference.

50 Apparatus as claimed in claim 49, characterised in that said control means are further adapted to derive a first predetermined region of interest of said field of view which encompasses all likely positions of the other end of the rolled smoking article or filter rod, when said one end is positioned at said first predetermined position, and said processing means are controlled to process said image only within said first predetermined region of interest to locate said other end.

51 Apparatus as claimed in claim 42 or claim 43, wherein said processing means are adapted for repeatedly sampling the image as a rolled smoking article or filter rod is rotated by said rotating means and processing each image sample to measure the diameter of said rolled smoking article or filter rod in each image sample and using the measurements to obtain one or more physical properties of said rolled smoking article or filter rod selected from the mean diameter, ovality, circumference, roundness and shape of said rolled smoking article and filter rod.

52 Apparatus as claimed in claim 51, wherein said processing means are adapted to locate in each image sample two opposite edges of the rolled smoking article or filter rod in profile and to calculate the distance between said opposite edges.

53 Apparatus as claimed in claim 52, further comprising control means for controlling said processing means, said control means comprising a database, which database is adapted to store a predetermined nominal diameter of said rolled smoking article or filter rod, said control means being adapted to define two laterally spaced regions of interest of said field of view corresponding to the nominal width, each of which regions of interest encompasses all likely positions of a respective one of the opposite edges, and said control

means are configured to control the processing means to process each image sample only within said two regions of interest to locate said opposite edges.

54 Apparatus as claimed in claim 51, claim 52 or claim 53, wherein said processing means are adapted to determine the diameter of said rolled smoking article or filter rod at two or more axially spaced locations on said rolled smoking article or filter rod.

55 Apparatus as claimed in any of claims 51 to 54, wherein said processing means are adapted to detect one or more circumferential markers on a rolled smoking article or filter rod which are capable of indicating its rotational orientation.

56 Apparatus as claimed in any of claims 51 to 55, further comprising control means adapted to control said rotating means in response to output from the processing means such that said rolled smoking article or filter rod is rotated through a complete revolution.

57 Apparatus as claimed in claim 48, claim 49 or claim 50, wherein said processing means are adapted to determine the axial length of an outer tipping layer of a rolled smoking article having first and second adjacent longitudinal sections, said tipping layer extending axially from a first end of the rolled smoking article over one of said first and second sections, overlapping the interface between said sections to cover partially the other section and terminating remote from said first end in an edge, and having an appearance which is distinct from that of the remaining non-overlapped portion of the other section.

58 Apparatus as claimed in claim 57, characterised in that said database is further adapted to store data indicating the axial orientation of the rolled smoking article and a second nominal length of said tipping layer between said edge and said first end, said control means being adapted derive from said second nominal length and, depending on the axial orientation of the rolled smoking article, the first nominal length a first nominal distance between said edge and said one end of the rolled smoking article, and to control the moving means to move the rolled smoking article to a second predetermined position with respect to said field of view corresponding to said first nominal distance such that said edge is disposed within said field of view, and thereafter to control said processing means to process said image to locate said edge with respect to said field of view and determine the actual length of the tipping layer from the position of the edge, the position of the one end and, depending on the orientation of the rolled smoking article, the actual length of the rolled smoking article.

59 Apparatus as claimed in claim 58, wherein said control means are further adapted to derive from said second nominal length and, depending on the axial orientation of the rolled smoking article, the first nominal length a second nominal position for said edge



with respect to the field of view when said one end is positioned at said second predetermined position, and said processing means are adapted to locate the actual position of said edge with respect to the field of view and determine the actual distance between said edge and said one end by calculating the difference between said actual and second nominal positions and adding or subtracting that difference to or from the first nominal distance, the actual length of said outer tipping layer being equal to the actual distance or, depending on the orientation of the rolled smoking article, the actual length of the rolled smoking article minus the actual distance.

60 Apparatus as claimed in claim 59, characterised in that said control means are further adapted to derive a second predetermined region of interest of said field of view which encompasses all likely positions of the edge of the tipping layer, when said one end is positioned at said second predetermined position, and said processing means are controlled to process said image only within said second predetermined region of interest to locate said edge.

61 Apparatus as claimed in claim 42 or claim 43, further comprising control means for controlling said processing means, said control means comprising a database adapted to store data indicating the axial direction of a rolled smoking article which is axially asymmetric such that said rolled smoking article is directional, said processing means being adapted for repeatedly sampling said image as said rolled smoking article is rotated by said rotating means and processing each sample to detect the position of a shadow cast by a longitudinal seam of an outer layer of the rolled smoking article, said outer layer being wrapped circumferentially around said rolled smoking article to overlap itself thereby to form said seam, thereby to determine the direction of wrapping of said outer layer relative to the direction of the rolled smoking article.

62 Apparatus as claimed in claim 61, characterised in that said database is further adapted to store a nominal width of said rolled smoking article, said control means being adapted to derive two laterally spaced regions of interest of said field of view based on said nominal width, each of said regions of interest encompassing all likely positions of said shadow depending on the direction of wrapping of said outer layer, and to control said processing means to detect the presence of said shadow only in one of said regions of interest.

63 Apparatus as claimed in claim 61 or claim 62, wherein said sidelights are positioned obliquely relative to the optical axis to enhance the shadow cast by said seam.

64 Apparatus as claimed in claim 61, claim 62 or claim 63, wherein said processing means are adapted to determine the respective wrapping directions of two or more outer layers of a rolled smoking article, each of which outer layers is wrapped circumferentially around the rolled smoking article to overlap itself to form an axially extending seam.

5 65 Apparatus as claimed in claim 39 or claim 40, wherein said processing means are adapted to detect any voids in the rolled smoking article or filter rod.

66 Apparatus as claimed in claim 39 or claim 40, further comprising control means for controlling said moving means and said processing means, said control means comprising a database adapted to store data indicating the axial orientation of a rolled smoking article, which rolled smoking article comprises a first filter section and a second adjacent tobacco rod section, and a third predetermined nominal length of said filter section, said control means being configured to derive from said third nominal length and, depending on the axial orientation of the rolled smoking article, the first nominal length, a second nominal distance between an end face of said filter section at the interface between said sections and said one end of the rolled smoking article, and to control the moving means to move the rolled smoking article to a third predetermined position with respect to said field of view corresponding to said second nominal distance such that said end face is disposed within said field of view, and thereafter to control said processing means to process said image to locate said end face with respect to said field of view and determine the actual length of the filter section from the position of the end face, the position of the one end and, depending on the orientation of the rolled smoking article, the actual length of the rolled smoking article.

67 Apparatus as claimed in claim 66, wherein said control means are further adapted to derive from said third nominal length and, depending on the axial orientation of the rolled smoking article, the first nominal length a third nominal position for said end face with respect to the field of view when said one end is positioned at said third predetermined position, and said processing means are adapted to locate the actual position of said end face with respect to the field of view and determine the actual distance between said end face and said one end by calculating the difference between said actual and third nominal positions and adding or subtracting that difference to or from the second nominal distance, the actual length of said filter section being equal to the actual distance or, depending on the orientation of the rolled smoking article, the actual length of the rolled smoking article minus the actual distance.

68 Apparatus as claimed in claim 67, characterised in that said control means are further adapted to derive a third predetermined region of interest of said field of view which encompasses all likely positions of the end face, when said one end is positioned at said third predetermined position, and said processing means are controlled to process said  
5 image only within said third predetermined region of interest to locate said end face.

69 Apparatus as claimed in claim 66, claim 67 or claim 68, wherein said processing means are further adapted to determine the axial length of an outer tipping layer which extends axially from a first end of the rolled smoking article over said first filter section and includes an overlapping portion that overlaps said interface between said sections to  
10 cover partially the second tobacco rod section and has an appearance which is distinct from that of the remaining non-overlapped portion of the second section, thereby to determine the length of said overlapping portion by calculating the difference between the length of the outer tipping layer and the length of the filter section.

70 Apparatus for determining one or more physical properties of a rolled smoking article having a first filter section, a second adjacent tobacco rod section, an outer layer being wrapped circumferentially around said second section to overlap itself thereby to form a first longitudinal seam, and an outer tipping layer, said tipping layer being wrapped circumferentially around said rolled smoking article to overlap itself thereby to form a second longitudinal seam and extending axially from a first end of the rolled smoking  
15 article over said first section, overlapping the interface between said sections to cover partially the second section and terminating remote from said first end in an edge, and having an appearance which is distinct from that of the remaining non-overlapped portion of the second section, said apparatus comprising:

an imaging device defining a field of view, said imaging device being adapted for  
25 forming a digital image of said smoking article in said field of view;

a positioning device adapted for positioning said smoking article in said field of view, said positioning device comprising a device for rotating said smoking article about its axis in said field of view and a device for moving said smoking article axially relative to the field of view;

30 a locating device for locating one end of the smoking article relative to the field of view

at least one illuminating device which is selectively operable for casting diffuse light onto said field of view for illuminating said field of view and/or for backlighting the smoking article positioned in said field of view;

a processing device which is adapted for sampling said digital image and for processing said image samples to determine one or more physical properties of a smoking article in said field of view;

5 a database adapted to store a first nominal length of said rolled smoking article, a second nominal length of said tipping layer between said edge and said first end, a third nominal length of said filter section, and user-inputted data indicating the axial orientation of the rolled smoking article on the jig;

a control device for controlling said moving device, said rotating device, said illuminating device and processing device, said control device being configured to:

10 (i) control said moving device to move the one end of the rolled smoking article or filter rod to a first predetermined position with respect to said field of view corresponding to said first nominal length such that the other end is disposed within said field of view, and thereafter to control said processing device to process said image to locate said other end with respect to the field of view and to determine the actual length of  
15 the rolled smoking article from the locations of said one and other ends;

(ii) control said processing device to process said image to locate two opposite edges of the rolled smoking article or filter rod in profile and to calculate the distance between said opposite edges;

(iii) derive from said second nominal length and, depending on the axial  
20 orientation of the rolled smoking article, the first nominal length a first nominal distance between said edge and said one end of the rolled smoking article, and to control the moving device to move the rolled smoking article to a second predetermined position with respect to said field of view corresponding to said first nominal distance such that said edge is disposed within said field of view, and thereafter to control said processing device  
25 to process said image to locate said edge with respect to said field of view and determine the actual length of the tipping layer from the position of the edge, the position of the one end and, depending on the orientation of the rolled smoking article, the actual length of the rolled smoking article;

(iv) control said rotating device to rotate said rolled smoking article about its  
30 axis and to control said processing device to sample repeatedly said image as said rolled smoking article is rotated and to process each sample to detect the position of a shadow cast by the first longitudinal seam of said outer layer, thereby to determine the direction of wrapping of said outer layer relative to the direction of the rolled smoking article

(v) control said rotating device to rotate said rolled smoking article about its axis and to control said processing device to sample repeatedly said image as said rolled smoking article is rotated and to process each sample to detect the position of a shadow cast by the second longitudinal seam of said tipping layer, thereby to determine the direction of wrapping of said outer layer relative to the direction of the rolled smoking article;

(vi) derive from said third nominal length and, depending on the axial orientation of the rolled smoking article, the first nominal length, a second nominal distance between an end face of said filter section at the interface between said sections and said one end of the rolled smoking article, and to control the moving device to move the rolled smoking article to a third predetermined position with respect to said field of view corresponding to said second nominal distance such that said end face is disposed within said field of view, and thereafter to control said processing device to process said image to locate said end face with respect to said field of view and determine the actual length of the filter section from the position of the end face, the position of the one end and, depending on the orientation of the rolled smoking article, the actual length of the rolled smoking article; and

(vii) control said processing device to determine the axial length of said overlapping portion of said tipping layer by calculating the difference between the length of the outer tipping layer and the length of the filter section.